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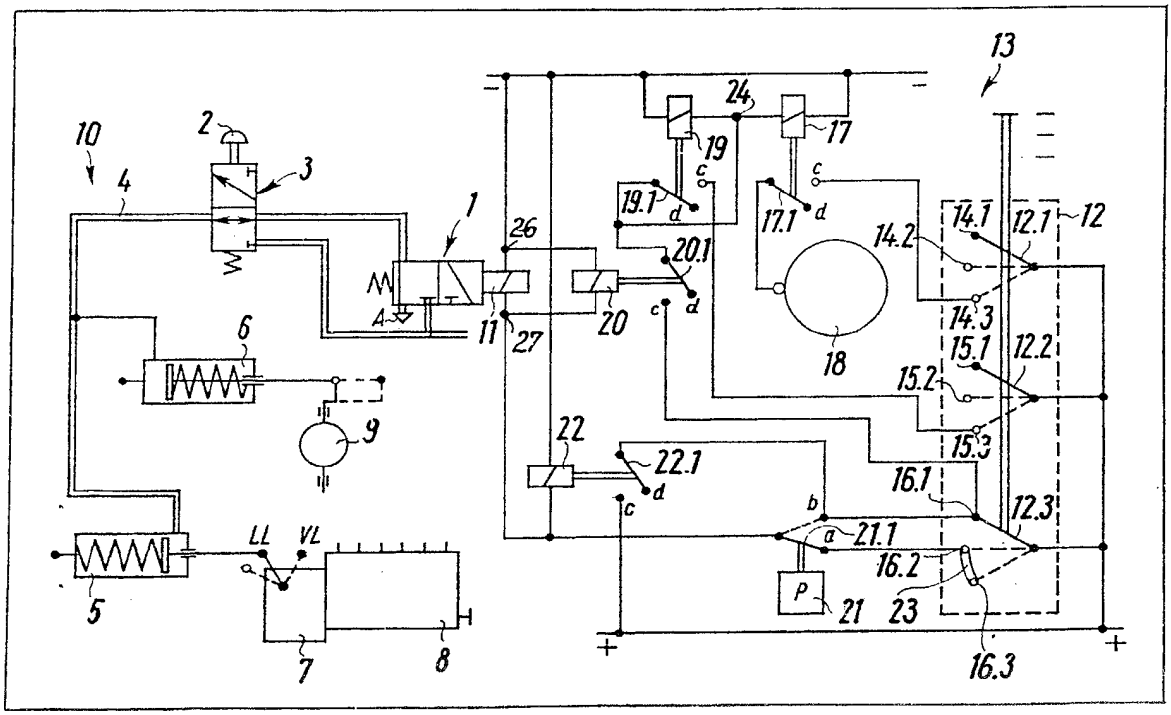
(54) **A starting and stopping system for an air-compressing fuel-injection internal combustion engine**

(57) A key-operated main switch (12) is located in an electrical control circuit (13) containing an oil pressure-responsive change-over switch (21) and a solenoid (11) of a 3/2-way valve (1). Pneumatic control circuit (10), in which the 3/2-way valve (1) is located controls compressed air cylinder (5) which is coupled to a regulator (7) of a fuel-injection pump (8). Switch (12) has a plurality of switching elements (12.1, 12.2, 12.3) which are shifted simultaneously into different positions, at least one branch of the electrical control circuit (13) being controlled by each switching element, and a relay control-unit (17, 19, 20, 22) being provided, which is activated to complete selected branches of the circuit (13), in dependence on the position of the main switch (12) and/or the position of the change-over switch (21).



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that compressed air is led to the compressed air cylinders 5, 6. The regulator 7 is thereby shifted, by means of the compressed air cylinder 5, into the "stop" position, whilst the exhaust flap 9 is simultaneously caused to take up the "closed" position. On de-energising the solenoid 11, the pressure in the compressed air line 4 is relieved to atmosphere at the point A, whereby the compressed air cylinders 5 and 6 become relieved of pressure, this enabling the regulator 7 to be shifted into the position L (idling) or VL (maximum power), whilst the exhaust flap 9 sumultaneously caused to take up the "open" position.

Activation of the solenoid 11, caused by the appropriate actuation of a main electrical switch 12, causes the fuel-injection internal combustion engine to stop, as will be further described below.

The system includes an electrical control circuit 13, which acts in such a way that the solenoid 11 of the valve 1 is energised or de-energised, depening on a specified position of the main switch 12. Provision is made, in accordance with the invention, for the main switch 12 to possess a plurality of switching elements. Three switching elements 12.1 and 12.3 are provided in the case of the embodiment illustrated, a group of switching contacts being respectively allocated to these elements, some of these contacts either being open or in connection with branches of the lectrical control circuit 13. The switching elements 12.1 to 12.3 of the main switch 12 are connected together and are connected to one terminal (+) of a battery. Their switching contacts 14.1 to 14.3 are allocated to the switching contacts 14.1 and 14.2 are open in the illustrated position of the switch 12, whilst the switching contact 14.3 is connected to a supply circuit for a starter means 18, through the switching element 17.1 of a relay 17. In this position of the switch 12, the switching element 12.2 has two open switching contacts 15.1 and 15.2 and a third switching contact 15.3, which is connected to a switching contact *c* of a relay 19. On switching the switching element 19.1 onto the contact 15.3 a current path between the switching contact 5.3 and the other terminal (—) of the battery is formed, through the switching element 1 and the relay 19.

Three switching contacts 16.1, 16.2 and 16.3 are allocated to the switching element 12.3 of the main switch 12. In the illustrated position of the switch 12, the switching contact 16.1 is connected to a contact *c* of a relay 20, it being possible to switch the switching element 20.1 of this relay between the contact *c* and a contact *d*. The switching element 20.1 is additionally connected to the switching element 19.1 of the relay 19. Furthermore, the switching contact 16.1 is connected to a contact *b* for a change-over switch 21, which functions in response to oil pressure, the contact *b* of this change-over switch being connected to a switching element 22.1 of the relay 22. The switching contact 16.2 and the switching contact 16.3 are connected together by a bridge 23 and are connected to a contact *a* of the change-over switch 21. The switching element 21.1 of the change-over switch 21, which can be switched-over between the contacts *a* and *b*, depending on the oil pressure present, is connected on turn to a connection of the relay 22 and of the solenoid 11. The other connection of the relay 22 and of the solenoid 11 are connected to the (—) terminal of the battery. Two contacts *c* and *d* are allocated to the switching element 22.1 of the relay 22. The relays 17, 19, 20 and 22, which are provided in the electrical control circuit, thus have a contact *c* and *d* allocated, in each case, to their respective switching element, the switching elements of the relays being, in each case, connected to the associated contact *c* when a voltage is applied to the relay in question, whilst, on the other hand, the switching element in question is connected to the contact *d* if the relays are in the de-energised condition. The contact *c*, which is allocated to the switching element 22.1 of the relay 22, is connected to the (+) terminal. The relay 20 is connected in parallel to the solenoid 11 of the valve 1 and a voltage is thus applied to this relay simultaneously to any activation of the solenoid 11. As shown in the drawing, the two relays 17 and 19 are connected together in parallel, the connection between the two relays 17 and 19 being connected to the switching elements 19.1 and 20.1.

The switching elements 12.1 to 12.3 of the main switch 12 can thus assume three different switching positions. The switching position allocated to the contacts 14.1, 15.1 and 16.1 corresponds to the switching position "Stop" of the main switch, the switching position defined by the contacts 14.2, 15.2 and 16.2 corresponds to the position "Drive", and the switching position defined by the contact 14.3, 15.3 and 16.3 corresponds to the position "Start".

In the following description, the mode of operation of the system is illustrated by reference to different switching processes. The different possible current paths of the electrical control circuit are described at the same time, in association with the operational states of the relays.

Parking:

The switching elements 12.1 to 12.3 assume the switching position corresponding to the switch position "Stop" as shown in the drawing. In this case, the switching elements 12.1 and 12.2 exercise no function in connection with making the electrical control circuit 13. The switching element 12.1 of the change-over switch 21 is switched onto the contact *a*, since no oil pressure is present. The relays 17, 19, 20 and 22 are not energised, because their switching elements are, in each case, switched onto the respective contact *d*. The solenoid 11 of the valve 1 is thus not energised and the regulator 12 is set in the position LL. At the same time, the circuit to the starter 18 is interrupted.

Undesired start caused by rolling:

The main switch 12 assumes the position "Stop". Due to the fact that the vehicle is rolling, the fuel-injection internal combustion engine is rotating and an engine-oil pressure is produced, as a result of which the switching element 21,1 is switched onto the contact *b*. A curent circuit is thereby formed, from the contact 16.1 through the contact *b* of the change-over switch 21 and the solenoid 11, to the (—) terminal, and the switching elements of the relays 17, 19, 20 and 22 are switched onto the contacts *c*. Because the solenoid 11 is now energised, the valve 1 reacts, and the regulator 7 is shifted into the "Stop" position. The starter means 18 is not actuated, because the switching element 12.1 of the main switch 12 is not positioned on the contact 14.3.

Switch operation through to start position:

The main electrical switch 12 is moved into the "Drive" position, the fuel-injection internal combustion engine being stationary. The vehicle is also stationary. There is consequently no engine-oil pressure and the switching element 21.1 of the change-over switch 21 is switched onto its contact *a*. In this state, the switching element 12.3 is located on the contact 16.2, as a result of which a circuit from the (+) terminal is closed, through the switching element 12.3, the associated contact *a* and the switching element 21.1, causing excitation of the solenoid 11 and of all the relays 17, 19, 20 and 22. The regulator 7 is shifted into the "Stop" position, although the starter means 18 is not operated, because the current circuit to the starter means 18 is still open at the contact 14.3.

Commencement of starting:

The main electrical switch 12 assumes the position "Start". The switching element 12.1 is now connected to the contact 14.3, and the switching elements 12.2 and 12.3 are respectively connected to the contacts 15.3 and 16.3. The switching element 12.3 establishes a current path to the solenoid 11, by means of the contact *a* and the switching element 21.1 of the change-over switch 21, which is still in the pressureless position *a*. All relays 17, 19, 20 and 22 are thereby simultaneously activated, and the associated switching elements of the relays are switched onto their contacts *c*. This action forms a current circuit to the starter means 18, because the switching element 12.1 is switched onto the contact 14.3 and the switching element 17.1 of the relay 17 is switched onto the contact *c*. The regulator 7 simultaneously assumes the "Stop" position.

Starting:

As a result of the "commencement of starting" process described above, the starter means 18 is operated, so that as the engine turns over an engine-oil pressure begins to be generated and the switching element 21.1 of the change-over switch 21 is switched over onto the contact *b*. The connection between the (+) terminal and the solenoid 11, by means of the switching element 12.3 is thereby interrupted and the relays 20 and 22 drop out, so that their contact elements 20.1 and 22.1 are switched onto their contacts *d*. However, the switching element 12.2 forms a current connection from the (+) terminal, via the switching element 19.1 (position *c*), to the connection point 24 between the two relays 17 and 19, and hence, via these relays or their solenoids, to the(—) terminal of the battery. By this means, the switching elements 17.1 and 19.1 are held in the switching position *c*, that is to say, the relay 19 is in a self-locking state, whilst the valve 1 is not activated, so that the starter means 18 continues to rotate the engine. The regulator 7 can thereby be shifted from the position LL into the position VL.

The main electrical switch 12 now assumes the "Drive" position, whilst the fuel-injection internal combustion engine is rotating. In this start, the vehicle itself may be stationary or may move. Due to the engine-oil pressure, the switching element 21.1 assumes the switching position *b*. All relays 17, 19, 20 and 22 are deactivated (position *d*), and the regulator 7 assumes the position LL or VL. The starter means 18 is not actuated.

Attempted starting when the fuel-injection internal combustion engine is running:

The main electrical switch 12 is moved into the "Start" position, whilst the fuel-injection internal combustion engine is simultaneously running. During this process, the vehicle can be stationary or it can be moving. Due to the engine-oil pressure, the switching element 21,1 of the change-over switch 21 is switched onto the contact *b*, whilst all relays 17, 19 20 and 22 as well as the solenoid 11 of the valve 1 are deactivated. The regulator 7 assumes the switching position LL or VL. Starter operation and/or starting is consequently impossible when the fuel-injection internal combustion engine is running.

Loss or failure of engine oil pressure:

If the engine-oil pressure falls or fails while the fuel-injection internal combustion engine is operating (the main switch 12 assumes the "Drive" position) the vehicle being stationary or on the move, the switching element 21.1 of the change-over switch is switched over onto the contact *a*. A current path to the solenoid 11 of the valve 1 is thereby produced, between the (+) terminal of the battery, the switching element 12.3, the contact 16.2, the contact *a* and the switching element 21.1.

The valve 1 reacts and causes the regulator 7 to shift to the "Stop" position. Emergency switching-off in the event of loss of oil is thus carried out.

Stopping the engine:

The main switch 12 must be brought into the "Stop" position in order to stop the fuel-injection combustion engine. The fuel-injection internal combustion engine will continue to rotate whilst the vehicle is stationary. An oil pressure is accordingly still present, that is to say, the switching element 21.1 of the change-over switch 21 is still switched onto the contact *b*. The relays 17, 19, 20 and 22 are activated, and a current path to the solenoid 11 is formed, through the switching element 12.3, the contact 16.1, the contact *b* and the switching element 21.1 so that the regulator 7 is shifted into the "Stop" position and the fuel-injection internal combustion engine is stopped. When the engine comes to rest, the change-over switch 21 then switches to the position *a*, and thereby vents the pneumatic system; the electrical system is also switched off.

The system according to the invention also permits the motor vehicle to be towed; in the following manner:—

For towing, the main switch 12 is brought to the "Drive" position, the switching element 21.1 being switched onto the contact *a* due to the fact that no oil pressure is present. As soon as the oil pressure rises, due to the movement of the vehicle and due to the fuel-injection internal combustion engine, which is not rotating, the change-over switch 21 switches over onto the contact b, so that the regulator 7 can be shifted between the positions LL and VL.

As in the case of Patent Application No. 7849743, a key is used to move the main electrical switch 12 into each of the three possible positions.

The system according to the invention thus guarantees that the fuel-injection internal combustion engine can be started only when oil pressure is present. The fuel-injection internal combustion engine is automatically stopped in the event of oil pressure failure, and undesired starting of the fuel-injection internal combustion engine, due for example to rolling on a slope, is also impossible. A fault in the electrical wiring system, caused, for example, by the breakage of a line, also prevents the fuel-injection internal combustion engine from being started. Switching-on of the starter means 18 whilst the fuel-injection internal combustion engine is running is prevented. An additional advantage is also that no stopping can occur whilst the fuel-injection internal combustion engine is running, even when, for example, a cable breaks while the vehicle is in motion, or when some other fault in the electrical system occurs.

The connections 26 and 27 are advantageously located as near as possible to the solenoid 11 of the valve 1, since a fault located between these connections does not prevent the starter from being actuated.

Finally, it is important that relay 19 be brought to self-excitation when the main switch 12 is in the "Start" position, since with-out self-excitation of this relay 19, the relay 17 would switch off, that is to say, the switching element 17.1 would be switched onto the contact *d*, so that the starter means 18 would be switched off and no oil pressure would build up. The starter means 18 however, must remain switched on slightly longer, in order to ensure reliable starting of the fuel-injection internal combustion engine.

The following table is a summary of the switching processes described in the preceding text, in assocation with the operating states of the motor vehicle and of the fuel-injection internal combustion engine.

Switching process	Main switch position 12	Engine operation	Vehicle operation	Engine oil pressure + pressure − no pressure 21	Relays + closed − open ++ self-locking 22	20	19	17	3/2-way valve 1	Injection pump setting	Starter + on − off 10	Remark
Parking	Stop	not running	stationary	−	−	−	−	−	−	LL	−	
Undesired rolling start	Stop	running	rolling	+	+	+	+	+	+	Stop	−	
Switch to starting position	Drive	not running	stationary	−	+	+	+	+	+	Stop	−	
Commence-ment of starting	Start	running	stationary	−	+	+	++	+	+	Stop	+	
Starting	Start	running	stationary	+	−	−	++	+	−	LL...VL	+	
Engine has started	Drive	running	stationary or moving	+	−	−	−	−	−	LL...VL	−	
Starting when engine is running	Start	running	stationary or moving	+	−	−	−	−	−	LL...VL	−	Switching-on or starting impossible when engine is running
Engine running, oil pressure fails	Drive	running	stationary or moving	−	+	+	+	+	+	Stop	−	Emergency switching-off in event of lack of oil
Engine is switched off	Stop	running	stationary	still +	+	+	+	+	+	Stop	−	

Towing: 1. Initially, still without oil pressure, as 4. 2. Towing after oil pressure has built up, as 6.

CLAIMS

1. A starting and stopping system for an air compressing fuel-injection internal combustion engine of a motor vehicle, said system including a key-operated electrical main switch which is located in an electrical control circuit containing a controllable presssure-sensitive change-over switch and a solenoid of a 3/2-way valve, and including a pneumatic control circuit, in which at least the 3/2-way valve is located and which controls at least one compressed air cylinder which is coupled to a regulator of a fuel-injection pump, in which system the elecrical control circuit including the electrical main switch influences the engine stopping means in dependence on a control signal from the internal combustion engine so that when the engine stopping means is actuated, the regulator of the fuel-injection pump initially moves to the "Stop" position and is moved to the "idle" position when the engine has stopped, wherein the electrical main switch is provided with a plurality of switching elements which can jointly be shifted into different switching positions, at least one part of the electrical control circuit being allocated to each switching element, and a relay control-unit is provided which can be activated in order to energise specific parts of the electrical control circuit in dependence on the position of the switching elements of the electrical main switch and/or the position of the change-over switch.

2. A system according to Claim 1 wherein the relay control-unit includes a first relay, the switching element of this relay being located in the current circuit to an engine starter means.

3. A system according to Claim 2, wherein a second relay is series-connected to the relay which is located in the current circuit of the starter means, the second relay being self-locking during the starting of the fuel-injection internal combustion engine in order to hold the first relay in the energised condition.

4. A system according to Claim 3, wherein the relay control-unit includes a third relay, connected in parallel with the soldnoid of the 3/2-way valve, the switching element of the third relay being series-connected to the switching element of the second relay.

5. A system according to Claim 4, wherein a fourth relay is connected in parallel with the solenoid of the 3/2-way valve and forms a circuit supplying current to the switching element of the third relay when there is no engine-oil pressure, so that the first and second relays are energised and an electrical circuit to the starter means is closed.

6. A system according to any one of the preceding claims, wherein the electrical main switch comprises three switching elements, three contacts are allocated to each switching element, a switching element is provided for completing a current circuit to the starter means, a further switching element is provided for forming a current circuit through the first and second relays, whilst a third switching element is provided for controlling the 3/2-way valve, by means of the pressure-sensitive change-over switch.

7. A key-operated starting and stopping system for an air-compressing fuel-injection internal combustion engine, substantially as hereinbefore described with reference to the accompanying drawing.

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